Space Weather Technical Forecast

Issued on Sunday, 31 October 2021 at 12:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrival still possible day 1 (31st) with G1/G2 Minor to Moderate storms likely and a chance of isolated G3 Strong Storm. G3 Watch issued.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was low, with a number of C-class flares from AR2891 Eac/Beta in the northeast. AR2887 Cso/Beta in the southwest has also continued to gradually simplify and dissipate. AR2892 Bxo/Beta in the northwest is both small and simple. The final region on the visible disk is a currently unnumbered region that has recently rotated around the northeast limb, currently analysed as a simple HSX/Alpha. No further Earth-directed CMEs have been observed in available imagery in the last 24 hours, though a CME left the Sun at 31/0706 UTC originating from a C2 flare from AR2891. This is awaiting further imagery for analysis.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR at L1 started at background, but gradually increased from near 300km/s to 450 km/s, reaching slightly elevated levels by 31/0915 UTC. Density values also increased from average levels to peak 38ppcc, before return back to average levels at 30/1900 UTC. A further enhancement occurred at 31/0915 UTC to above average values with a second peak at 19ppcc. The interplanetary magnetic field (IMF), Bt, was weak at first but increased to moderate levels of 8-13nT between 30/1530-2130 UTC then again after 31/0915 UTC. The north-south component, Bz also increased from background levels to be predominately negative (southward) between 30/1930-2300 UTC with peak value -11nT. Bz then returned to background until 31/1035 uTC when it became predominantly moderately negative with a maximum of -11nT again at 31/1132 UTC. Phi angle was in a largely negative direction (towards the Sun), but rotated to positive after 30/2030 UTC. These parameters indicate the potential of two weak CME's passing Earth, one late on 30th UTC and one after 0915 UTC on the 31st. Both are notably weaker than the anticipated CME arrival. Resultant geomagnetic activity was Quiet (Kp0-2), but increased to Active 30/2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured by GOES-16 was at S1/ Minor Storm values at first, peaking at 13 pfu, before declining to be below the S1 level from 30/2200 UTC. The high energy electron flux (greater than 2 MeV) was predominantly at background levels with the associated 24-hour electron fluence below the Active (1e8 integrated pfu) threshold, with 1.2e6 integrated pfu recorded at 31/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is forecast is forecast to be Low over the next 4 days with a slight chance of further M-class flares, primarily from AR2891.

Solar Wind / Geomagnetic Activity: A notable CME from an X-class flare eruption on the 28th is still forecast to arrive at Earth on the 31st. There have been some recent indications of elevated activity in the solar wind parameters, but these are significantly weaker than expected and much later than anticipated. Geomagnetic activity is still expected to increase to give Minor

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to Moderate geomagnetic storms (G1/G2 Kp5-6), with a diminishing chance of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside during the day 2 into day 3 (1st and 2nd) with an eventual return to Quiet to Unsettled, with a chance of Active intervals (Kp2-4). A further solar wind enhancement is possible day 4 (3rd) due to the arrival of the fast wind of CH16, becoming Unsettled to Active with a chance of G1/Minor Storms.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be below the S1 minor storm level, decreasing to background through the period. The high energy electron flux (greater than 2 MeV) is forecast to remain mostly at background levels between day 1 (31st), but with a risk of exceeding the Active level (1e3pfu) threshold at times later by day 2 as geomagnetic activity following the expected CME arrival subsides. The associated 24 hour fluence is expected to remain largely below the Active (1e8 integrated pfu) level, but with a slight chance of exceeding this threshold by day 3 (2nd).

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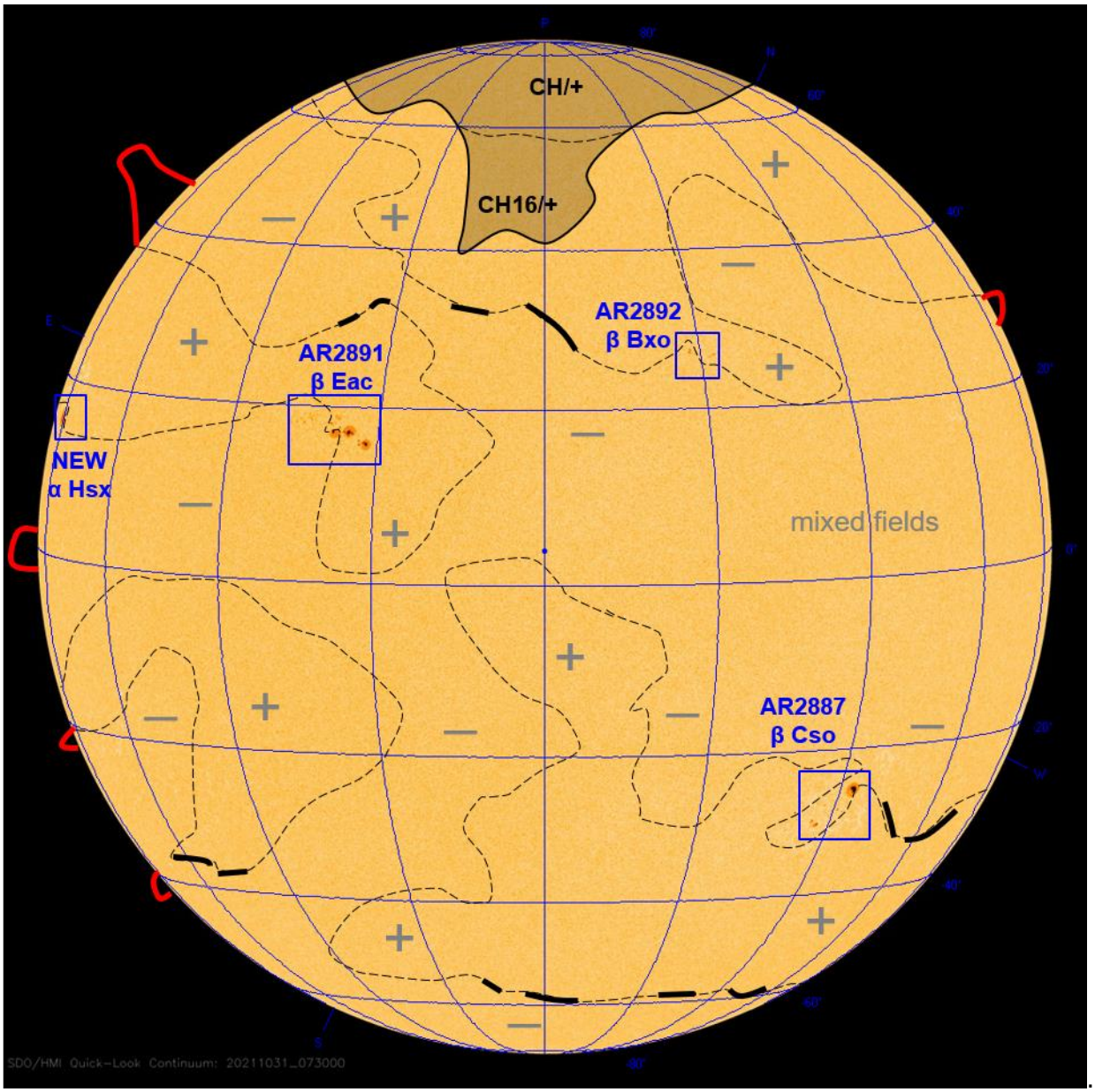
Figure 1. Solar Analysis Valid 31/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A large full-halo CME was observed leaving the sun in coronagraph imagery following the X-class flare from AR2887 on the 28th at 1535 UTC. This feature was analysed as Earth-directed was expected 30/1200-2400 UTC, but has yet to arrive. There have been some recent indications of elevated activity in the solar wind parameters, but these are significantly weaker than expected for this given CME and much later than anticipated. There remains a good chance that this CME will arrive at Earth at some point on the 31st, but with increasing time the risk of stronger geomagnetic storms and greater impacts generally decreases. A further smaller and slower CME that occurred on the 26/2000 UTC likely gave a minor glancing impact on passing Earth during the PM of 30th October UTC.

The arrival of the faster CME is expected to bring a sudden increase in solar winds, perhaps to 500-600 km/s, with solar winds then gradually easing to background as the CME subsides day 2 onward (1st Nov). A further enhancement is then possible day 4 from the arrival of the fast wind of positive polarity coronal hole 16 which is a southern extension of the northern polar crown.

Geomagnetic activity is forecast to soon increase to give Minor to Moderate Geomagnetic storms (G1/G2) with the CME arrival, and a chance of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside day 2 (1st) and into day 3 (2nd) with eventual return to Quiet to Unsettled levels, with a chance of Active intervals (Kp2-4). There is then a chance of G1/Minor storm intervals, perhaps day 3 (2nd) but more likely day 4 (3rd) from any fast wind arrival from CH16.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	40	10	30
Strong	G3	No	40	5	1	1
Severe	G4	No	5	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
28/2026	Full Halo	X Flare AR2887	SW Limb	600-900	31st	Reanalysis due to lack of evidence of large CME arrival

Figure 2:SWPC Solar wind parameters.

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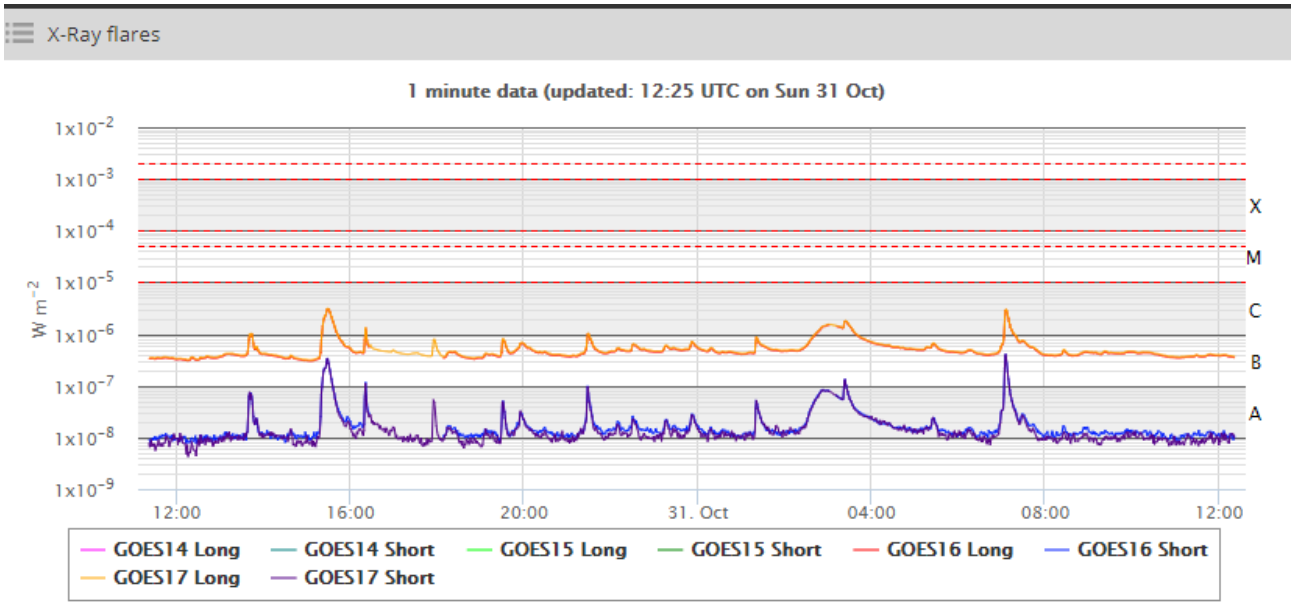
Radio Blackouts - X-Ray Flares:

Solar Activity is currently Low, with four sunspot containing active regions, and a number of C-class flares observed, primarily from AR2891 Eac/Beta, a CME left the Sun at 31/0706 UTC originating from a C2 flare from this region. This region still has the potential for M-class flares. AR2887 Cso/Beta has also continued to decay, since its X1-flare on the 28th. AR2892 Bxo/Beta, a region in the northwest is small and simple. Finally, a new region has recently rotated round the northeast limb, currently analysed as a simple Hsx/Alpha spot.

Solar Activity is expected to remain at Low levels, with a slight chance of increasing to Moderate.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	20	20
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: Xray trace



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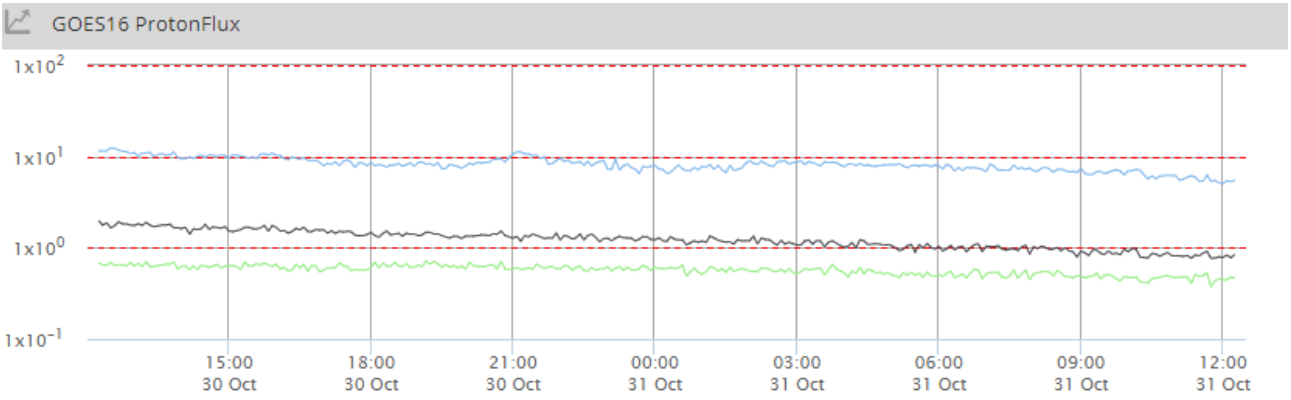
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently just below S1/Minor storm levels, having declined from S1 through the last 24 hours. Whilst likely staying below this level, with a gradual trend towards background through the period, there is a chance of further brief increases above S1 on day 1, these likely coinciding with any CME arrival.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	20	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Proton Trace past 24 hours



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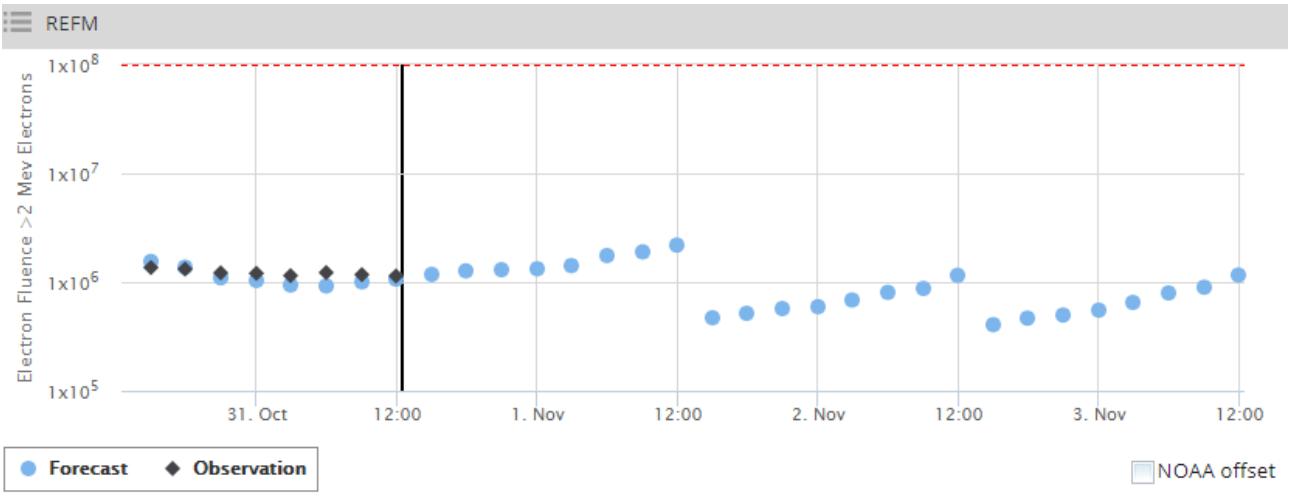
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2 MeV) as observed by GOES-16 at GEO is currently at background levels and expected to persist at this or moderate levels for much of the period. The still anticipated, but late arrival of the CME on day 1 (31st) has the potential to inject electrons into the Van Allen radiation belts. As geomagnetic activity subsides day 3 (1st) onward, the observed electron flux has the potential to increase to above the alert threshold (1000 pfu) although confidence is low. This will give a chance of reaching the Active fluence threshold (1e8 integrated pfu) from late day 2 onward (1st). REFM doesn't take account of the expected CME arrival, so whilst a good guide to current background conditions, will be of limited value when this arrives.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	30	30	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: REFM fluence model and forecast.



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